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# APPLICATION OF AND ENHANCEMENT TO ARCTIC INFRASTRUCTURE FOR THE STUDY OF LONG-TERM CHANGE IN THE EARTH'S POLAR MESOSPHERE

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Award Number: N00014-00-1-0658

## Status of Effort

Our Summer 2000 preliminary study of HF-PMSE is published in *Geophysical Research Letters*. We carried out a full climatological study at HIPAS and a long campaign at HAARP in Summer 2001. Our work in 2002 included preliminary 139-MHz studies and collection of MF data from Poker Flat corresponding to the HIPAS observations. Our goal in 2003 is to complete the data collection for C. Ramos' thesis, hopefully with multiple radar observations at HAARP. Finally, we have submitted a paper dealing with new rocket observations in the Arecibo heater beam to the *Journal of Geophysical Research*.

## Accomplishments/New Findings

Progress has been very satisfying during the last three summer seasons. In 2000 we performed a proof of concept experiment to show that HAARP could be used as an HF radar to study Polar Mesospheric Summer Echoes. The project was sufficiently successful to warrant a publication in *Geophysical Research Letters* [Kelley et al., 2002]. The 2001 Summer School project of Michael J. Nicolls also led to a publication in the *Journal of Geophysical Research* [Collins et al., 2003].

In the summer of 2001 we made more extensive observations and extended our observations to the Fairbanks area to enable more of a climatological study and to prepare for possible future joint experiments with the Poker Flat lidar and the MF radar. The former was not yet capable of daytime observations but we are very actively working with Denise Thorsen, a new professor at UAF, on the MF/HF comparisons from 2001 and 2002. This is an exciting area, since we are certain we can detect HF PMSE, but there is a lot of skepticism about the MF capability. This is a very interesting radioscience problem, i.e., why is it relatively easy to get PMSE echoes with a narrow beam antenna but difficult with a side beam MF system? If we can use MF reliably for PMSE studies it opens many other observational possibilities, e.g., at McMurdo and Manson stations in the Antarctic. We also had a successful campaign at HAARP in which both O and X mode scatter was used to see if we could estimate the absorption effects on the S/N. We also ran more diagnostics, trying to answer some questions we had after the first campaign.

We also supported a campaign by Frank Djuth using the HAARP 139 MHz radar. Due to instrumentation problems, that radar was still not running when we had to leave HAARP, but two days later they obtained a set of reasonable echoes. We worked with ONR to administer a subcontract for completion of the 139 MHz radar in Summer 2002. The final report [Djuth and Elder, 2003] for this effort is quite interesting and shows the viability of the HAARP observatory for natural as well as heater-induced studies.

We hope to complete that data collection needed for C. Ramos' thesis in Summer 2003. Our plan is to run regularly at HAARP (3 days per week) and support a two-week intense campaign with up to four radars in operation for PMSE studies.

Finally, we have completed analysis of the second rocket flight through the Arecibo heater beam. A paper is submitted to the *Journal of Geophysical Research* [Gelinas et al., 2003] and the reviews are favorable. Two results from this cold start heating experiment are notable. We detected HF power above the reflection height which seems to indicate a z-mode was generated. A number of proto-filaments were observed. Most curious were intense irregularities detected where the local plasma frequency equaled a harmonic of the electron cyclotron frequency. This seems to suggest that electron Bernstein waves were generated and then heavily damped at these heights.

## Bibliography

- Collins, R., M.C. Kelley, M. Nicolls, C. Ramos, T. Hou, T.E. Stern, K. Mizutani, and T. Itabe, Simultaneous lidar observations of a noctilucent cloud and an internal wave in the polar mesosphere, *J. Geophys. Res.*, 108(D8), 8435, doi:10.1029/2002JD002427, 2003.
- Djuth, F.T., and J.H. Elder, *Upgrade of the HAARP VHF Radar and Data Results from the Summer 2002 Campaign*, Geospace Research, Inc., El Segundo, CA, 2003.
- Gelinas, L., M.C. Kelley, E. Mishin, M. Starks, T. Franz, and M. Sulzer, In-situ observations during an HF heating experiment at Arecibo: Evidence for Z-mode and electron cyclotron harmonic effects, *J. Geophys. Res.*, submitted, 2003.
- Kelley, M.C., M. Huaman, C.Y. Chen, C. Ramos, F. Djuth, and E. Kennedy, Polar mesosphere summer echo observations at HF frequencies using the HAARP Gakona Ionospheric Observatory, *Geophys. Res. Lett.*, 29(12), 1603, doi:10.1029/2001GL013411, 2002.

## **Personnel Supported**

Editor I – 4% CY

Michael C. Kelley, P.I.: summer, salary recovery

Camilo Ramos, graduate student: summer

## **New Publications**

Collins, R., M.C. Kelley, M. Nicolls, C. Ramos, T. Hou, T.E. Stern, K. Mizutani, and T. Itabe, Simultaneous lidar observations of a noctilucent cloud and an internal wave in the polar mesosphere, *J. Geophys. Res.*, 108(D8), 8435, doi:10.1029/2002JD002427, 2003.

Gelinas, L., M.C. Kelley, E. Mishin, M. Starks, T. Franz, and M. Sulzer, In-situ observations during an HF heating experiment at Arecibo: Evidence for Z-mode and electron cyclotron harmonic effects, *J. Geophys. Res.*, submitted, 2003.

Kelley, M.C., M. Huaman, C.Y. Chen, C. Ramos, F. Djuth, and E. Kennedy, Polar mesosphere summer echo observations at HF frequencies using the HAARP Gakona Ionospheric Observatory, *Geophys. Res. Lett.*, 29(12), 1603, doi:10.1029/2001GL013411, 2002.

## **Interactions/Transitions**

Ionospheric Effects Symposium (IES2002), May 7-9, 2002

CEDAR Workshop, Boulder, CO, June 16-21, 2002

Fall AGU Meeting, December 6-10, San Francisco, CA, 2002

EGS - AGU - EUG Joint Assembly - 7-11 April 2003, Nice, France, 2003

(Replaces Spring AGU meeting)

9<sup>th</sup> Annual RF Ionospheric Interactions Workshop, Santa Fe, NM, April 27-30, 2003

## **New Discoveries**

None.

## **Honors/Awards**

Member, American Geophysical Union

Fellow, American Geophysical Union

Senior Member, IEEE

Weiss Presidential Fellow for Excellence in Teaching

James A. Friend Family Distinguished Professor of Engineering

Fulbright Scholar, Fall, 2002